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## (54) Vulcanizable rubber composition for treads of vehicle tyres

(57) A vulcanizable rubber composition is described comprising a cross-linkable unsaturated chain polymeric base, wherein is incorporated at least one organic compound, solid at room temperature, selected from the group comprising: amorphous or semicrystalline polymers, oligomers, low-molecular weight organic substances and mixtures thereof, which compound is substantially insoluble in the polymeric base and shows a

first or second order transition temperature of from 80 to 160°C. Such rubber composition allows the manufacture of treads with either a low rolling resistance at the temperature of normal use of the tyre (40°-70°C), or a high grip when the tread is subjected to thermal stresses exceeding such temperatures.

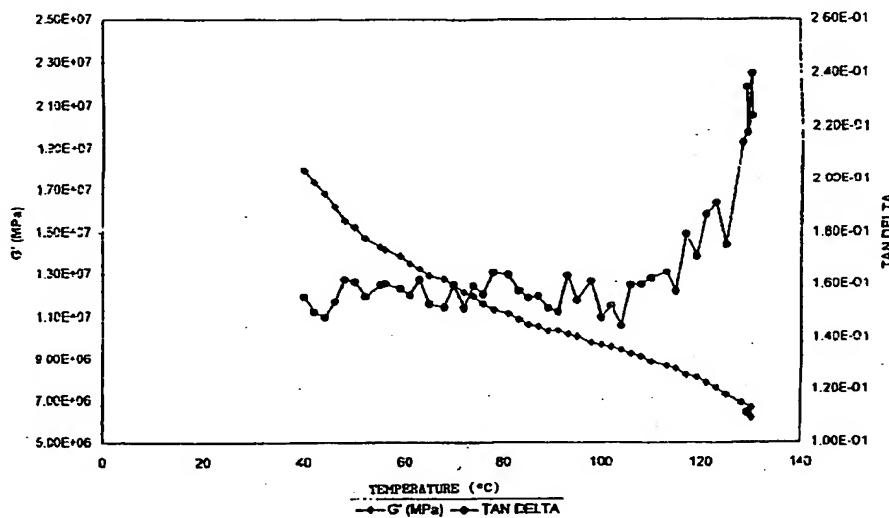


FIG. - 2

**Description**

The present invention relates to a vulcanizable rubber composition of the type comprising a cross-linkable unsaturated chain polymeric base, which has a preferred, while not exclusive, use in the manufacture of treads for vehicle tyres.

The invention also relates to a tread and a tyre obtainable by the above composition.

In the following description and in the subsequent claims, the terms: cross-linkable unsaturated chain polymeric base, are used to indicate any non cross-linked polymer, either natural or synthetic, capable of assuming all the physico-chemical and mechanical characteristics typical of elastomers as a result of cross-linking (vulcanization).

As is known, in the manufacture of vehicle tyres and, more particularly, of tyres having very high performances, one of the more difficult problems to solve has always been that of achieving either a low rolling resistance at the temperatures of normal use of the tyre (40-70°C), or an adequate road holding (grip) when the tyre exceeds said temperatures as a result of high thermo-mechanical stresses, such as, for instance, those ensuing from a so-called "borderline" use of said tyre.

It is also known that the difficulty of simultaneously achieving these desired characteristics essentially stems from the fact that they are affected in a completely opposite manner by the hysteretic characteristics, i.e. by the amount of dissipated energy, of the rubber composition that constitutes the tyre tread.

In order to achieve the desired low rolling resistance of the tyre, in fact, it is necessary to use rubber compositions with a low hysteresis value, and as such suitable to dissipate limited energy amounts during rolling.

On the other hand, in order to achieve the desired high road grip, it is necessary to use rubber compositions having a high hysteresis value, and as such suitable to dissipate energy amounts apt to ensure a high grip between the tread and the ground.

The solution to this problem is even more difficult if it is considered that the rubber composition constituting the tyre tread should possess hysteretic behaviours quite opposite and incompatible with one another, depending upon the working temperature range of the tyre.

All the attempts made in the art to improve tyre performances within a temperature range above those normally used, in fact, have met either a marked and undesired increase in rolling resistance, or a substantial worsening of the abrasion resistance characteristics of the tread.

These disappointing attempts were substantially based on the use in the rubber composition of hydrocarbon resins substantially soluble in the SBR-containing polymeric bases typically used in the production of treads for vehicle tyres, such as for example alpha-methylstyrene-derived resins (such as the resin marketed under the trade name KRISTALEX™ F-85, produced by Hercules, Wilmington, Delaware, U.S.A.) or coumarone-based resins.

The ensuing practical consequence is that the above problem has not been solved yet in the art.

As a consequence, the technical problem underlying the present invention is that of providing a rubber composition having a different hysteretic behaviour depending upon the working temperature of the tyre, so as to obtain either a low rolling resistance at the temperatures of normal use of the tyre (40-70°C), or an adequate road holding (grip) when the tyre exceeds said temperatures as a result of high thermo-mechanical stresses.

According to the present invention, it has surprisingly been found that the desired low rolling resistances at the above working temperatures of the tyre and high grip in borderline working conditions of the same, may be simultaneously achieved provided that at least one organic compound, solid at room temperature, is incorporated in the polymeric base of the rubber composition used to manufacture the tread, which compound:

- a) should be substantially insoluble in said polymeric base; and
- b) should have a first or second order transition temperature of from 80 to 160°C.

Preferably, said organic compound is selected from the group comprising: amorphous or semicrystalline polymers, oligomers, low-molecular weight organic substances and mixtures thereof.

Preferably, the polymers of the invention have an average numeric molecular weight of from 10,000 to 1,000,000.

For the purposes of the invention, polymers of preferred and advantageous use are those selected from the group comprising: polyphenylenether, polyethylene, polypropylene, polymethyl-methacrylate, polystyrene, polyvinylalcohol, ethylene/vinyl alcohol copolymers, acrylonitrile-butadiene-styrene (ABS) terpolymers, ethylene-methacrylic acid copolymers, styrene-isoprene (SIS), styrene-butadiene (SBS), styrene-ethylene/butylene-styrene (S-E/B-S), and styrene-ethylene/propylene (S-E/P) block copolymers and mixtures thereof.

Optimum results have been achieved with polyphenylenether having a glass transition temperature of 120°C, marketed by Hüls under the trade name VESTORAN™ 1100.

Preferably, the oligomers of the invention have an average numeric molecular weight of less than 10,000, and more preferably of from 500 to 10,000.

For the purposes of the invention, oligomers of preferred and advantageous use are those selected from the group

comprising aliphatic or aromatic hydrocarbon resins having an average numeric molecular weight comprised in the above-defined range.

Optimum results have been achieved either with the aliphatic hydrocarbon resins marketed by Hercules under the trade name PICCOPALE™ 100 and PICCOTAC™ 95, or with the aromatic hydrocarbon resin marketed by Hercules under the trade name ENDEX™ 155.

For the purposes of the invention, the aforementioned low-molecular weight organic substances have a molecular weight of up to about 300 and are preferably selected from the group comprising: aromatic and aliphatic hydrocarbons, phenols, alkyl halides, aldehydes, quinones, anhydrides, organic acids, amides, and mixtures thereof.

Among them, the following are preferred: phenanthrene, catechol, resorcinol, iodoform, carbon tetrabromide, m-oxybenzaldehyde, p-nitrobenzaldehyde, p-benzoquinone, succinic anhydride, azelaic acid, caproamide, valeramide, benzamide, and mixtures thereof.

In the following description and in the appended claims, the term: first order transition temperature, is used to indicate the temperature at which the thermodynamic state functions such as, for instance, enthalpy, entropy or volume, show a point of discontinuity, i.e. a sudden change as temperature varies.

In the case of the semicrystalline polymers of the invention, such temperature corresponds to the disgregation of the crystalline domains existing in the polymer matrix (melting) and takes place within a more or less wide range of values. This is due to the non uniform regularity degree of the crystalline domains or to the presence of defects of variable nature and extent within the same.

The amorphous polymers of the invention do not show this type of transition.

In the following description and in the subsequent claims, the term: second order transition temperature, or glass transition temperature ( $T_g$ ), is used to indicate the temperature that separates the hard and brittle (glass) state from the rubbery state of the polymer, i.e., the temperature above which the macromolecular chains of the polymer are capable of deforming, changing their conformation through heat-activated jumps, and under which the movement of the various segments of such macromolecular chains is substantially barred (see M. Rink, "The polymers: structure and technological implications", Proceedings of XVII Meeting AIM School, Polymeric Materials: Structure and Processability, Gargano, 1995).

Both the semicrystalline polymers (limitedly to the amorphous part) and the amorphous polymers of the invention show this type of transition.

In the following description and in the subsequent claims, the expression: organic compound substantially insoluble in a given polymeric base, is used to indicate a compound such that the  $tg\delta$  curve as a function of temperature of the vulcanized rubber composition, as determined by means of experimental techniques known per se, for instance by using the commercially available equipments of Rheometrics with a temperature sweep from -120°C to +140°C, shows a peak in correspondence of each first or second order transition temperature of said polymeric base and, respectively, of said compound.

In this case, in fact, the above compound even if it is incorporated in the mass of the polymeric base, it does not dissolve in the latter, but forms, instead, a number of "islands" in said mass which retain the physico-chemical and viscoelastic (hysteretic) characteristics of the solid compound.

It has been found that when the compound added to the polymeric base shows the combination of features mentioned hereinabove, the resulting rubber composition allows to obtain a tread with a low rolling resistance at the temperatures of normal use of the tyre (40-70°C) and, at the same time, a high grip when the tread temperature exceeds such values as a result of thermo-mechanical stresses to which it is submitted.

In particular, with the rubber compositions of the invention it has been observed, after vulcanization, a variation in the tread hysteresis values along with the temperature increase and above a threshold value near the transition temperature of the above compound.

Near this threshold value, the energy dissipation due to tread hysteresis undergoes a sudden increase and reaches values suitable to ensure an adequate road holding (grip) of the tyre.

The tests carried out have also showed that the higher the tread temperature, the more marked is the phenomenon of energy dissipation, with a corresponding advantageous frictional grip increase just when the tyre works at its borderline conditions.

According to a further advantageous aspect of the invention, the temperature at which a variation in the hysteresis values of the vulcanized rubber composition begins to appear, may be determined in advance, depending upon the selected polymeric base, by selecting a rubber composition having the desired transition temperature.

According to the tests carried out, in fact, the increase in energy dissipation due to hysteresis begins to show, in the case of the compounds considered, in the vicinity of the first or second order transition temperature of the same.

Vice versa, when the rubber composition of the tread does not undergo high thermo-mechanical stresses and works at a temperature of 40-70°C, energy dissipation by hysteresis is substantially determined by the "polymeric base" component of the rubber composition itself.

In other words, it has been observed that within such temperature range the compounds of the invention do not appreciably affect the hysteretic behaviour of the vulcanised rubber composition.

As a consequence, by appropriately selecting the ingredients of the rubber composition, it is possible to achieve either a low rolling resistance at the temperature of normal use of the tyre, or a high grip when its working temperature increases.

According to the invention, improved characteristics of mechanical resistance of tyre tread, such as for instance strength at break, abrasion resistance and tear resistance, have been obtained when the above compound solid at room temperature is also substantially compatible with the above polymeric base of the rubber composition.

The expression: compound substantially compatible with a given polymeric base, is used to indicate in the following a compound such that the abradability of the vulcanized rubber composition, determined according to the DIN 53516 standards, does not exceed 120% of the abradability value - measured in the same test conditions - of the same composition without said at least one compound.

In such a case, in fact, the above compound, though being insoluble in the mass of the polymeric base, may anyway disperse homogeneously in the latter and establish with the molecules of the polymeric base physico-chemical bonds which keep anyhow unaltered the mechanical characteristics and the abradability of the rubber composition.

Within the framework of the invention, therefore, a compound may be defined as compatible with a given polymeric base if it does not induce in the rubber composition the typical effects of an inert filler, such as for instance a marked worsening of the abradability characteristics of the same.

Among the polymeric bases useful for the purposes of the invention, those preferred are unsaturated chain polymers or copolymers obtained by polymerization of conjugated dienes and/or aliphatic or aromatic vinyl or vinylidene monomers.

More particularly, the polymeric bases of the invention may be selected from the group comprising: natural rubber, 1,4-cis polybutadiene, polychloroprene, 1,4-cis polyisoprene, optionally halogenated isoprene-isobutene copolymers, butadiene-acrylonitrile, styrene-butadiene and styrene-butadiene-isoprene terpolymers, either prepared in solution or in emulsion, ethylene-propylene-diene terpolymers.

According to the invention, such polymeric bases may be used either individually or mixed with one another, according to the desired characteristics of the finished product.

Preferably, the polymeric bases of the invention comprise from 20 to 100% by weight of a styrene-butadiene copolymer.

According to the invention, it is particularly advantageous to incorporate in the rubber composition from 2 to 30 parts by weight, preferably from 5 to 15 parts by weight, of the above high-transition temperature compound per each 100 parts by weight of polymeric base.

When the rubber composition comprises such a quantity of compound, in fact, the treads obtainable therefrom have given excellent results in terms of low rolling resistance at the temperatures of normal use of the tyre (40-70°C) and of high grip when the tyre is brought to borderline use conditions.

It has also been found that when the quantity of compound is under 2 parts by weight per each 100 parts of polymeric base, its effect on the hysteresis values of the rubber composition at high temperature is reduced, while above 30 parts by weight the beneficial effects on the grip of the tyre are more than counterbalanced by the worsening of the mechanical characteristics of the tread.

As to the lower limit of the transition temperature of the compounds of the invention, it has been noticed that when such temperature is under about 80°C, an undesired increase in tread rolling resistance is found.

As to the upper limit of 160°C of the transition temperature of the compounds of the invention, higher temperature values do not seem to provide, on the contrary, substantial benefits in the case of treads of normal use in vehicle tyres, since such temperature value is unlikely to be reached even in the most extreme conditions of use.

In any case, the choice of the compound with the most suitable transition temperature may be effected by a man skilled in the art according to the type of vehicle on which the tyre must be mounted.

According to a preferred embodiment and for the purpose of having a low rolling resistance at the temperatures of normal use of the tyre (40-70°C), the rubber compositions of the invention are of the so-called low carbon black content type, in which the latter is partly or entirely replaced by so-called "white" inorganic reinforcing fillers, such as gypsum, kaolin, bentonite, titanium dioxide, silicates of various type and silica.

In a preferred embodiment, the rubber compositions of the invention incorporate at least a silica-based reinforcing filler and a suitable binding agent capable of chemically reacting with silica and of binding the latter to the polymeric base during the vulcanization of the same.

In the following description and in the subsequent claims, the term: silica-based reinforcing filler, is used to indicate a reinforcing agent based on silicon dioxide (silica), silicates and mixtures thereof, having a surface area, measured according to the BET method, of from 100 to 300 m<sup>2</sup>/g.

To the sole purpose of simplifying this description, the silica-based fillers of the invention will be indicated in the following by the term: silica.

According to the invention, it is particularly advantageous to incorporate in the rubber composition from 10 to 80 parts by weight of silica per each 100 parts by weight of polymeric base.

When the rubber composition incorporates such a quantity of silica, in fact, optimum results have been reached in

tyres obtainable therefrom, in terms either of mechanical characteristics, or of reduction in the rolling resistance.

According to a preferred embodiment of the invention, the rubber composition incorporates one or more non cross-linking ingredients, known per se, necessary to impart to the rubber composition the necessary mechanical and workability characteristics.

5 Such ingredients are selected in particular from the group comprising reinforcing fillers, such as for instance carbon black, plasticizers, working adjuvants, antioxidants, age-retarding agents, etc.

Each of such ingredients is also chosen in amounts and proportions which may be easily determined by those skilled in the art.

10 The rubber composition, furthermore, is made vulcanizable by adding and incorporating therein a suitable vulcanizing agent, optionally and preferably together with suitable vulcanization activators and accelerators.

If the polymeric base is selected from the preferred cross-linkable unsaturated chain polymers, the vulcanizing agent of most advantageous use is sulphur, or sulphur-containing molecules (sulphur donors), with accelerators and activators well known to those skilled in the art.

15 Among vulcanization activators, zinc stearate, formed directly in the rubber composition by adding zinc oxide and stearic acid, is preferred.

By way of non-limitative illustration, there is specified in the following a preferred recipe of a rubber composition according to the invention (in parts by weight):

20	- polymeric base	100
	- high-transition temperature compound	5 - 15
25	- carbon black	0 - 80
	- silica	0 - 80
	- ZnO	1 - 5
30	- Stearic acid	0 - 5
	- antioxidants	1 - 3
	- anti-fatigue agents	0.5 - 3
	- sulphur or donors of same	0.5 - 3
	- accelerators	0.5 - 3
35	- plasticizers	0 - 40

The above-identified rubber composition may be obtained by means of mixing operations conventional per se and well known to those skilled in the art, which will not be described in detail.

40 According to a further aspect of the invention, a tread is provided with a low rolling resistance at the temperatures of normal use of tyre (40-70°C), and a high road holding (grip) when the tyre exceeds such temperatures as a result of high thermo-mechanical stresses, obtainable by forming a vulcanizable rubber composition of the type described hereinabove.

45 Preferably, the tread of the invention is formed by drawing, moulding or calendering at a temperature of from 80 to 120°C.

Advantageously, the tread - once vulcanized with operations known per se - shows an increase in energy dissipation by hysteresis and, as a result, in the road holding of the tyre above a threshold temperature proximate to the transition temperature of the high transition temperature organic compound of the invention.

50 Thanks to the compatibility of said compound with the polymeric base of the rubber composition, furthermore, the tread of the invention advantageously shows an abradability value, measured according to DIN 53516, not greater than 120% of the abradability value of a tread of the same composition without said compound.

According to a further aspect of the invention, a process is provided for the manufacture of tyres for vehicle wheels, comprising the steps of providing around the circumference of a carcass a tread externally provided with a rolling surface, and linking by vulcanization said carcass to said tread, which is characterized in that said tread is obtained by forming a vulcanizable rubber composition of the type described hereinabove.

55 According to a further aspect, the invention also refers to a tyre for vehicle wheels whose tread shows an increase in energy dissipation by hysteresis and, as a result, in road holding as the temperature increases and starting from temperature values proximate to the transition temperature of the aforementioned compound and in every so-called borderline use conditions.

Quite surprisingly, tyres manufactured according to the process of the invention, when subjected to road tests and compared with tyres fully identical but incorporating a tread manufactured according to the prior art, have given much better results, as will be seen in the following.

Therefore, according to yet a further aspect, the invention concerns a process for improving tyre behaviour on road, which is characterized in that the tyre tread is obtained by forming a vulcanizable rubber composition of the type described hereinabove.

Further characteristics and advantages will be better apparent by the following description of some examples of vulcanizable rubber compositions, tread and tyres according to the invention, given by way of non-limitative illustration, with reference to the attached drawings.

In the drawings:

- Fig. 1 shows a partly interrupted cross section of a tyre according to the invention;
- Fig. 2 shows the values of  $\text{tg}\delta$  and modulus of elasticity  $G'$  as a function of the temperature of a preferred rubber composition according to the invention.

With reference to Fig. 1, a tyre 1 conventionally comprises at least a carcass ply 2 whose opposite side edges are externally bent around bead wires 3, incorporated each in a bead 4, defined along an internal circumferential edge of the tyre where the tyre itself engages on a wheel rim 5 making part of the wheel of a vehicle.

Along the circumferential development of the carcass ply 2, one or more belt strips 6, made of textile or metal cords incorporated into a rubber composition sheet, are applied.

Externally to the carcass ply 2, in respective opposed side portions thereof, a couple of sidewalls 7 is applied, each of which extends from the bead 4 up to a so-called "shoulder" 8 of the tyre, defined in correspondence of opposite ends of the belt strips 6.

Onto the belt strips 6 a tread 9 is circumferentially applied whose side edges end in correspondence of the shoulders 8 joining with the sidewalls 7. The tread 9 has an external rolling surface 9a, designed to contact the ground, wherein circumferential grooves 10 may be obtained, intercalated by transversal grooves, not shown in the attached figure, which define a plurality of tread blocks 11 variously distributed along said rolling surface 9a.

The above described tyre 1 may be manufactured by means of a process including a plurality of production steps which are quite conventional per se and known in the art.

More particularly, such process comprises the steps of preliminarily and independently preparing several semi-finished products corresponding to the different parts of the tyre (carcass plies, belt strips, bead wires, fillings, sidewalls and treads), which are subsequently assembled to one another by a suitable assembling machine.

The subsequent vulcanization step then welds together the above semi-finished products to form a monolithic block, i.e. the tyre.

Clearly, the step of preparing the above semi-finished products is preceded by a step of preparing and forming the corresponding rubber compositions.

In the tyres of the invention, the tread 9 is produced by forming a vulcanizable rubber composition of the type described hereinabove.

#### EXAMPLE 1

In a closed rotor mixer (Banbury) model F270 of the company POMINI, which had been caused to rotate at a speed of about 40 rpm, the following ingredients were charged in sequence:

- E-SBR = butadiene-styrene copolymer prepared in emulsion, having a styrene content of 23%;
- polyphenylenether = VESTORAN 1100 (Hüls);
- carbon black = N115 type (Cabot Corporation);
- silica = BET 175 m<sup>2</sup>/g, VN3 type (Degussa);
- silane-based binder = Si69 [bis(2-triethoxysilylpropyl)tetrasulfide] (Degussa);
- age-retarding agent = 6PPD, also known as SANTOFLEX 13 (Monsanto);
- anti-fatigue agent = TMQ, also known as VULCANOX 4020 (Bayer).

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as well as other commonly used ingredients in smaller amounts.

The rubber composition obtained was charged, after cooling down to room temperature, in a closed rotor mixer (Banbury) model 11D of the company POMINI, which had been caused to rotate at a speed of about 20 rpm, together with the following ingredients:

5

- sulphur;
- vulcanization accelerators [diphenylguanidine DPG (Monsanto) and SANTOCURE NS (Monsanto)].

10 The rubber composition was then submitted to intimate mixing, so as to disperse the vulcanizing system, taking care to keep the temperature of the composition at a value equal to about 100°C, so as not to initiate undesired phenomena of premature vulcanization.

After about 3', 170 kg of a vulcanizable rubber composition were discharged, comprising in parts by weight:

15

- polymeric base	100
- polyphenylenether	8
- carbon black	35
- silica	30
- binding agent	8% of silica
- ZnO	2
- stearic acid	1
- antioxidants	2.5
- antifatigue agents	1
- plasticizers	15
- sulphur	1.2
- accelerators	2.5

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EXAMPLES 2-5

According to the procedure described in the preceding Example 1, rubber compositions were prepared having the 40 compositions shown in Table 1 herunder.

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TABLE I

Ingredients	Ex. 2	Ex. 3	Ex. 4	Ex. 5
S-SBR	100	-	-	75
E-SBR	-	75	75	-
NR	-	25	-	-
BR	-	-	25	25
carbon black	20	50	70	20
cpds. of inv.	15	5	7	10
silica	50	15	-	50
binding agent	5	1.5	-	5
ZnO	2	2	2	2
Stearic acid	1	1	1	1
antioxidants	2.5	2.5	2.5	2.5
sulfur	1.5	1.5	1.5	1.5
accelerators	2	2	2	2
S-SBR = butadiene-styrene copolymer prepared in solution, having a content of styrene of 26%, a content of 1,4-trans bonds of 26% and of vinyl groups of 60%;				
NR = natural rubber;				
BR = polybutadiene having a content of 1,4-cis bonds equal to 93%.				

The compounds of the invention used were the following:

Ex. 2 = S-E/B-S block copolymer, commercially available under the trade name KRATON™ G-1651 (Shell);

Ex. 3 = ethylene-methacrylic acid copolymer (8.7%), commercially available under the trade name NUCREL™ 0910 (E.I. Du Pont De Nemours);

Ex. 4 = polyphenylenether, commercially available under the trade name VESTORAN™ 1100 (Hüls);

Ex. 5 = polyethylene, commercially available under the trade name RIBLENE™ MR10 (Enichem).

Other ingredients: as in Example 1.

#### EXAMPLE 6

##### (Determination of the hysteretic properties of the rubber composition)

A sample of the rubber composition according to the preceding Example 1 was submitted to vulcanization with methods and apparatuses known per se, and then to several tests to evaluate its hysteretic properties as a function of the temperature.

More particularly, the values of  $\tan \delta$ , defined as:

$$\tan \delta = G''/G'$$

wherein:

G": modulus of loss [MPa]

G': modulus of elasticity [MPa]

5 and of the modulus of elasticity G', were determined in a range of from 40° to 130°C, with experimental methods known per se and using apparatuses marketed by the Company Rheometrics.

The tests were carried out on strip-shaped test samples having a width of 12±0.2 mm, a thickness of 2±0.2 mm and a length of 40 mm (working length 24 mm), which were torsion stressed with an amplitude equal to 0.1% and a frequency of 1 Hz by means of a rheometer model "Rheometer R.D.A. 700" (Rheometrics), commonly available on the market.

10 The end temperature of 130°C was reached by submitting the test sample to a temperature sweep at a heating speed equal to about 2°C per minute.

15 The results of the tests carried out are graphically shown in the attached Figure 2, wherein the average values out of 8 tests of the modulus of elasticity G' (MPa) and, respectively, of  $\text{tg}\delta$  (dimensionless), are shown on the ordinates, while the temperature (°C) is shown on the abscissa.

20 As may be easily appreciated from the figure, while the modulus of elasticity G' progressively decreases as the temperature increases, the value of  $\text{tg}\delta$ , proportional to the energy dissipation by hysteresis of the rubber composition, remains substantially constant from 40 to 100°C, and has a sudden increase starting from about 100°C, near the glass transition temperature of the polyphenylenether included in said composition.

25 As a result, the aforementioned rubber composition undergoes a drastic increase in its energy dissipation by hysteresis and, along therewith, in the tread grip, just in correspondence of the temperature range which is reached by the tread when the same is subjected to severe thermo-mechanical stresses (borderline conditions).

Therefore, in such conditions, the tread exerts such a high frictional grip on the ground which is indispensable for a good road holding of the tyre.

## EXAMPLE 7

### (Determination of the abradability characteristics of the rubber composition)

30 A sample of the rubber composition according to the preceding Example 1 was submitted to vulcanization with methods and apparatuses known per se, and then to several tests to evaluate its abradability characteristics.

Such parameter was assumed, in first approximation, as proportional to the compatibility degree between the high transition temperature polymer and the polymeric base of the rubber composition.

35 The tests were carried out according to the DIN 53516 standard, both on the vulcanized rubber composition incorporating polyphenylenether of the preceding Example 1, and on a vulcanized rubber composition of the same composition but without polyphenylenether (comparison composition).

40 In the abradability test, 129 mm<sup>3</sup> of material of the comparison vulcanized rubber composition and 140 mm<sup>3</sup> of the vulcanized rubber composition of the invention were removed, with an increase in abradability equal to about 8% (i.e., with an abradability value equal to about 108% of that of the comparison composition), well suitable to satisfy the abradability requisites required to a tread for vehicle tyres.

## EXAMPLE 8

### (Road behaviour)

45 With the rubber compositions obtained according to the preceding Example 1, several treads were produced by drawing in conventional apparatuses, which treads were then assembled on to 235/40-18 size tyres.

The tyres so obtained were then submitted to several standard tests - carried out at the Imola racing track on BMW cars model M5 - to evaluate their road behaviour in borderline use condition ("Hard Handling").

50 In all the tests performed, the tyres incorporating treads manufactured with the rubber composition of the preceding Example 1, were evaluated taking as a reference the tyres manufactured with a rubber composition of the same composition but without polyphenylenether (comparison tyres).

At the end of the test, a rate from 0 to 10 was assigned by the test driver to each of the evaluation parameters examined.

55 Table II shows the results so obtained, expressed as average values of the evaluations made by two different tests drivers.

TABLE II

Parameters	Ex. 1	comparison
effort at steering wheel	6	5
gearing promptness	6	4
balance*	5	4
compliance	6	4
curve release	6	4
handling	6	4

\* = both oversteering and understeering

As may be observed from the table reported hereinabove, the tyres of the invention performed markedly better with respect to the tyres manufactured according to the prior art.

More particularly, not only a marked improvement of road holding in the test borderline conditions was observed, but also an increase of the resistance to stresses over time, which in the case of the tyres of the invention was equal to about six times that provided by the comparison tyres.

#### Claims

1. A vulcanizable rubber composition of the type comprising a cross-linkable unsaturated chain polymeric base, characterized in that it further comprises at least one organic compound, solid at room temperature, substantially insoluble in said polymeric base and having a first or second order transition temperature of from 80 to 160°C.
2. A vulcanizable rubber composition according to claim 1, characterized in that said at least one organic compound is selected from the group comprising: amorphous or semicrystalline polymers, oligomers, low-molecular weight organic substances and mixtures thereof.
3. A vulcanizable rubber composition according to claim 1, characterized in that said at least one organic compound is a polymer selected from the group comprising: polyphenylenether, polyethylene, polypropylene, polymethylmethacrylate, polystyrene, polyvinylalcohol, ethylene/vinyl alcohol copolymers, acrylonitrile-butadiene-styrene (ABS) terpolymers, ethylene-methacrylic acid copolymers, styrene-isoprene (SIS), styrene-butadiene (SBS), styrene-ethylene/butylene-styrene (S-E/B-S), and styrene-ethylene/propylene (S-E/P) block copolymers and mixtures thereof.
4. A vulcanizable rubber composition according to claim 1, characterized in that said at least one organic compound is an oligomer having an average numeric molecular weight of less than 10,000, selected from the group comprising the aliphatic or aromatic hydrocarbon resins.
5. A vulcanizable rubber composition according to claim 1, characterized in that said at least one organic compound is a low-molecular weight substance selected from the group comprising: aromatic hydrocarbons, aliphatic hydrocarbons, phenols, alkyl halides, aldehydes, quinones, anhydrides, organic acids, amides, and mixtures thereof.
6. A vulcanizable rubber composition according to claim 5, characterized in that said at least one organic compound is a low-molecular weight substance selected from the group comprising: phenanthrene, catechol, resorcinol, iodoform, carbon tetrabromide, m-oxybenzaldehyde, p-nitrobenzaldehyde, p-benzoquinone, succinic anhydride, azelaic acid, caproamide, valeramide, benzamide, and mixtures thereof.
7. A vulcanizable rubber composition according to claim 1, characterized in that it comprises from 2 to 30 parts by weight of said at least one organic compound per each 100 parts by weight of said polymeric base.
8. A vulcanizable rubber composition according to claim 1, characterized in that said at least one organic compound is substantially compatible with said polymeric base.

9. A vulcanizable rubber composition according to claim 1, characterized in that said cross-linkable unsaturated chain polymeric base is selected from the group comprising: natural rubber, 1,4-cis polybutadiene, polychloroprene, 1,4-cis polyisoprene, optionally halogenated isoprene-isobutene copolymers, butadiene-acrylonitrile, styrene-butadiene and styrene-butadiene-isoprene terpolymers, either prepared in solution or in emulsion, ethylene-propylene-diene terpolymers, and mixtures thereof.

10. A vulcanizable rubber composition according to claim 9, characterized in that said cross-linkable unsaturated chain polymeric base comprises from 20 to 100% by weight of a styrene-butadiene copolymer.

10 11. A vulcanizable rubber composition according to claim 1, characterized in that it further comprises at least a silica-based reinforcing filler.

15 12. A vulcanizable rubber composition according to claim 11, characterized in that it comprises from 10 to 80 parts by weight of said silica-based reinforcing filler per each 100 parts by weight of said polymeric base.

15 13. A vulcanizable rubber composition according to claim 11, characterized in that said silica-based reinforcing filler has a surface area of from 100 to 300 m<sup>2</sup>/g.

20 14. A vulcanizable rubber composition according to claim 11, characterized in that it further comprises at least a silane-based silica binding agent.

25 15. A tread for high-grip vehicle tyres, obtainable by forming a vulcanizable rubber composition comprising at least a cross-linkable unsaturated chain polymeric base and at least one organic compound, solid at room temperature, substantially insoluble in said polymeric base and having a first or second order transition temperature of from 80 to 160°C, according to anyone of claims 1-14.

30 16. A tread according to claim 15, characterized in that it has an abradability value, measured according to DIN 53516, not greater than 120% of the abradability value of a tread having the same composition without said at least one organic compound.

35 17. A process for manufacturing a tyre for vehicle wheels of the type comprising the steps of circumferentially providing around a carcass (2) a tread (9), externally provided with a rolling surface (9a), and of linking by vulcanization said carcass (2) to said tread (9), characterized in that said tread (9) is obtainable by forming a vulcanizable rubber composition comprising at least a cross-linkable unsaturated chain polymeric base and at least one organic compound, solid at room temperature, substantially insoluble in said polymeric base and having a first or second order transition temperature of from 80 to 160°C, according to anyone of claims 1-14.

40 18. A tyre (1) for vehicles, comprising:

- at least a carcass ply (2) anchored at opposite edges to a couple of bead wires (3), incorporated each in corresponding beads (4) defined along internal circumferential edges of said tyre (1);
- at least a belt strip (6) extending circumferentially around said carcass ply (2);
- a tread (9) comprising at least a reinforcing filler dispersed throughout a polymeric base, circumferentially placed around said belt strip (6) and externally having a rolling surface (9a) apt to roll on the ground,

45 characterized in that said tread (9) is obtainable by forming a vulcanizable rubber composition comprising at least a cross-linkable unsaturated chain polymeric base and at least one organic compound, solid at room temperature, substantially insoluble in said polymeric base and having a first or second order transition temperature of from 80 to 160°C, according to anyone of claims 1-14.

50 19. A vehicle tyre according to claim 18, characterized in that it has an abradability value, measured according to DIN 53516, not greater than 120% of the abradability value of a tyre of the same composition and without said at least one polymer.

55 20. A process to control the road behaviour of tyres, in particular high-performance tyres, said tyres being provided with at least a carcass ply (2) anchored at opposite edges to a couple of bead wires (3), incorporated each in corresponding beads (4) defined along internal circumferential edges of said tyres, with at least a belt strip (6) extending

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circumferentially around said carcass ply and having a tread (9) circumferentially placed around said belt strip (6), externally having a rolling surface (9a) suitable to roll on the ground, characterized in that said tyre tread (9) is obtainable by forming a vulcanizable rubber composition comprising at least a cross-linkable unsaturated chain polymeric base and at least one organic compound, solid at room temperature, substantially insoluble in said polymeric base and having a first or second order transition temperature of from 80 to 160°C, according to anyone of claims 1-14.

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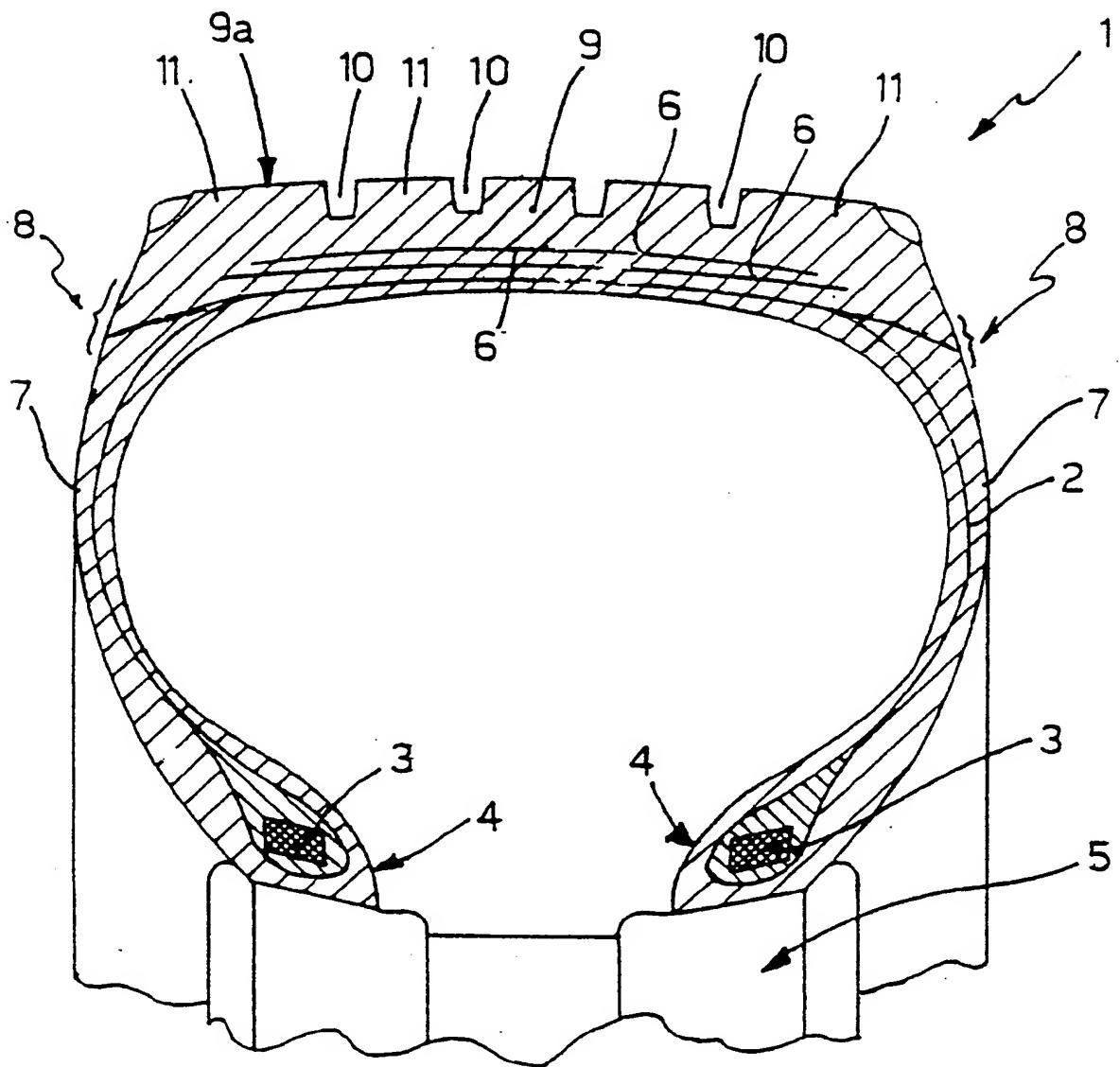


FIG.1

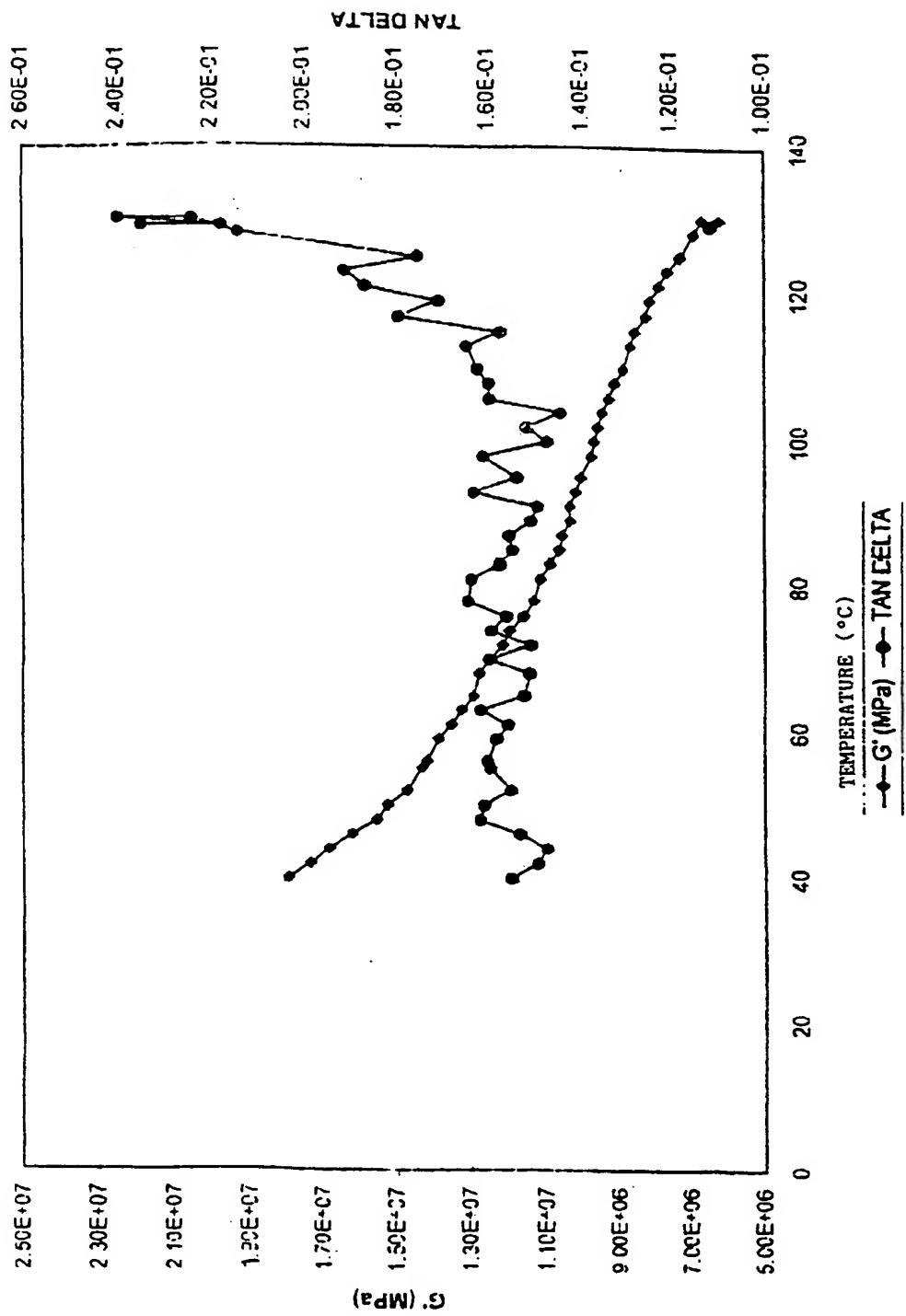


FIG. - 2



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 117 834 (THE GOODYEAR TIRE & RUBBER COMPANY) * claim 1 *	1-3,7-20	B60C1/00 C08L21/00 C08K5/00
X	EP-A-0 470 693 (BRIDGESTONE CORPORATION) * claim 5 *	1-3,7-20	
X	EP-A-0 351 054 (SUMITOMO RUBBER INDUSTRIES LIMITED) * claim 1 *	1-3,7-20	
X	FR-A-2 524 472 (BRIDGESTONE TIRE AND JAPAN SYNTHETIC RUBBER) * claim 1 *	1-3,7-20	
X	DATABASE WPI Week 8546 Derwent Publications Ltd., London, GB; AN 287200 XP002017220 & JP-A-60 197 751 (TOYO RUBBER) , 7 October 1985 * abstract *	1,4,7-20	
X	DATABASE WPI Week 9242 Derwent Publications Ltd., London, GB; AN 345103 XP002017221 & JP-A-04 249 551 (SUMITOMO CHEM) * abstract *	1,5-20	B60C C08L C08K
A	US-A-5 162 409 (T.S.MROCKOWSKI) * claim 1; figure 1 *	11-14, 17-20	
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	30 October 1996	Van Humbeeck, F	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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